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THE HOUSE FLY

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THE PRESENCE of flies is an indication of uncleanliness, insanitary conditions, and improper disposal of substances in which they breed. They are not only annoying; they are actually dangerous to health, because they may carry disease germs to exposed foods.

It is therefore important to know where and how they breed, and to apply such knowledge in combating them. This bulletin gives information on this subject. Besides giving directions for ridding the house of flies by the use of screens, fly papers, poisons, and flytraps, it lays especial emphasis on the explanation of methods of eliminating breeding places and preventing the breeding of flies.

THE HOUSE FLY.[1]

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KINDS OF FLIES FOUND IN HOUSES.

SEVERAL species of flies are found commonly in houses. Some of them so closely resemble the true house fly that it requires very careful observation to distinguish them from it.

One of these is the biting stable fly (fig. 1). It occurs frequently in houses and differs from the house fly in the important particular that its mouth parts are formed for piercing the skin. This fly is so often mistaken for the house fly that most people think that the house fly can bite.

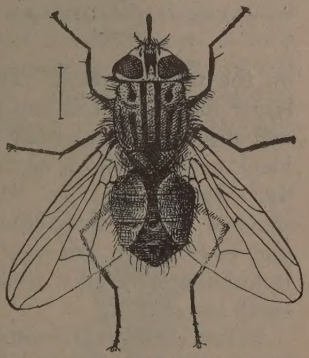

FIG. 1.—The stable fly or biting house fly (*Stomoxys calcitrans*). Much enlarged.

Another frequent visitant of houses, particularly in the spring and fall, is the cluster fly.[2] It is somewhat larger than the house fly, and is distinguished by its covering of fine yellowish hairs. Occasionally this fly occurs in houses in such numbers as to cause great annoyance. It gets its name of "cluster fly" from its habit of collecting in compact groups or clusters in protected corners during cold periods. In the maggot stage it is parasitic on certain angleworms, especially a common greenish colored earthworm.

Another species, which almost exactly resembles the house fly, is the stable fly shown in figure 2. It does not bite as does the biting stable fly. It breeds in decaying vegetable matter and in excrement.

Several species of metallic greenish or bluish flies also are found occasionally in houses. These include the blowfly or meat fly,[3] the blue-bottle (fig. 3) and the green-bottle (fig. 4) flies. They breed in decaying animal matter.

There is still another species, smaller than any of those so far mentioned, which is sometimes called the "lesser house fly."[4] A related

[1] *Musca domestica* L. [2] *Pollenia rudis* Fab. [3] *Calliphora erythrocephala* Meig. [4] *Fannia canicularis* L.

species is shown in figure 5. The "lesser house fly" is distinguished from the ordinary house fly by its paler and more pointed body. The male, which is commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen

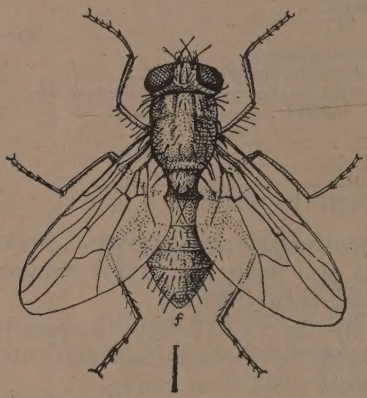

FIG. 2.—A stable fly (*Muscina stabulans*). Much enlarged.

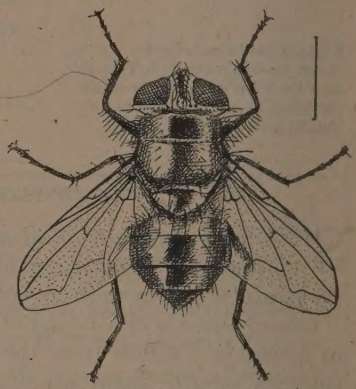

FIG. 3.—One of the blue-bottle flies (*Phormia terraenovae*). Much enlarged.

on the window pane. These little flies are not the young of the larger flies. Flies do not grow after the wings have once expanded and dried. Still another fly, and this one is still smaller, is a jet black species known as the window fly.[1] Its larva is a white, very slender, almost threadlike creature and is found in cracks of the floor in buildings, where it feeds on other small insects.

In late summer and autumn many specimens of a small fruit fly, known as the "vinegar fly" (fig. 6), make their appearance, attracted by the odor of overripe fruit.

All of these species, however, are greatly dwarfed in numbers by the common house fly. In 1900 the senior author made collections of the flies in dining rooms in different parts of the country, and found that the true house fly made up 98.8 per cent of the whole number captured. The remainder comprised various species, including those mentioned above.

FIG. 4. One of the green-bottle flies (*Lucilia caesar*). Much enlarged.

[1] *Scenopinus fenestralis* L.

WHERE THE TRUE HOUSE FLY LAYS ITS EGGS.

The true house fly (fig. 7), which is found in nearly all parts of the world, is a medium-sized fly with four black stripes on the back and a sharp elbow in one of the veins of the wings. The house fly can not bite, its mouth parts being spread out at the tip for sucking up liquid substances.

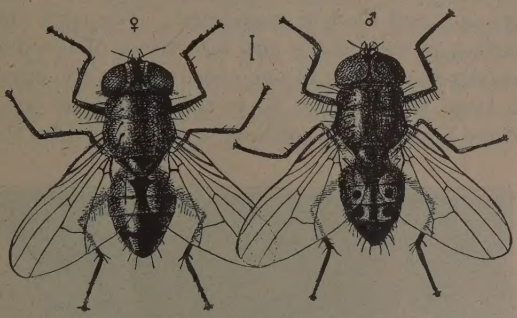

FIG. 5.—A "little house fly" (*Fannia brevis*): Female at left, male at right. Much enlarged.

The eggs (figs. 8, 9) are laid upon horse manure. This substance seems to be its favorite larval food. It will breed also in human excrement, and because of this habit it is very dangerous to the health of human beings, carrying as it does the germs of intestinal diseases, such as typhoid fever and cholera, from the excreta to food supplies. It has also been found to breed freely in hog manure and to some extent in cow and chicken manure. Indeed, it will lay its eggs on a great variety of decaying vegetable and animal materials,

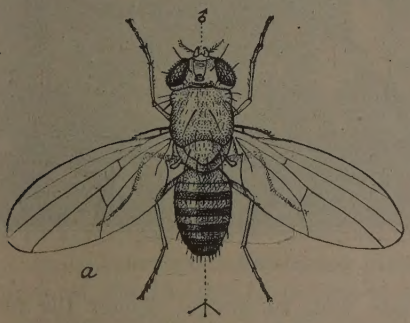

FIG. 6.—The vinegar fly (*Drosophila ampelophila*). Much enlarged.

FIG. 7.—The true house fly (*Musca domestica*). Enlarged.

but of the flies that infest dwelling houses, both in cities and on farms, a vast proportion come from horse manure.

It often happens, however, that this fly is very abundant in localities where little or no horse manure is found, and in such cases it breeds in other manure or in slops or fermenting vegetable material, such as spent hops, moist bran, ensilage, or rotting potatoes. Accumulations of organic material on the dumping grounds of towns and cities often produce flies in great numbers.

The number of eggs laid by an individual fly at one time undoubtedly is large, probably averaging about 120, and as a single female will lay at least two and possibly four such batches, the enormous numbers in which the insects occur are thus plainly accounted for, especially when the abundance and universal occurrence of appropriate larval food is considered. The eggs are deposited below the surface in the cracks and interstices of the manure, several females usually depositing in one spot, so that the eggs commonly are found in large clusters (fig. 8) in selected places near the top of the pile, where a high degree of heat is maintained by the fermentation below.

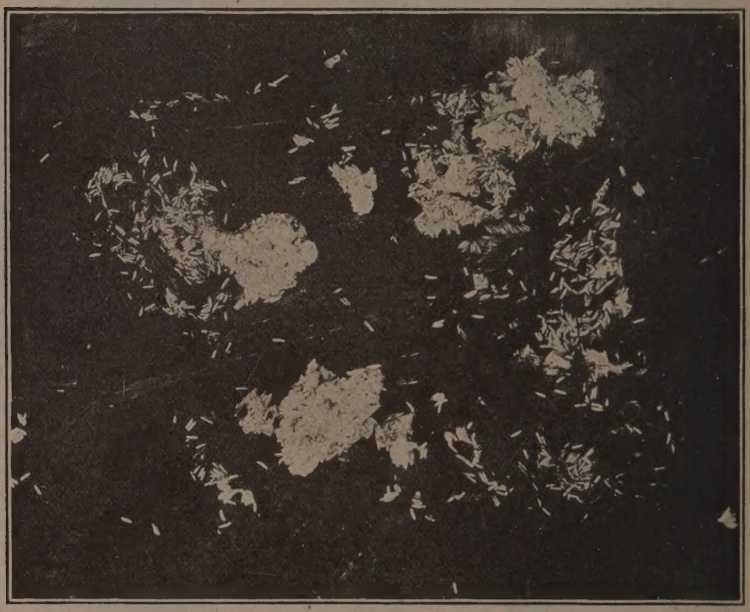

FIG. 8.—Eggs of the house fly. About natural size. (Newstead.)

The eggs usually hatch in less than 24 hours. Under the most favorable conditions of temperature and moisture the egg state may last hardly more than eight hours. The maggots which issue from the eggs are very small and transparent. They grow rapidly, completing the growth of the larva stage in four or five days. The larva period may be prolonged greatly by low temperature or by dryness or scarcity of the larval food. As the larvæ (fig. 10) attain full size they gradually assume a creamy white color. Just before pupation they become very restless and migrate from their feeding ground in search of a favorable place in which to pass the pupa stage. They will often congregate at the edges of manure piles near the ground or

burrow into the soil beneath, or they may crawl considerable distances away from the pile to pupate in the ground or in loose material under the edges of stones, boards, etc.

The pupæ (fig. 11), or "sleepers," are more or less barrel shaped and dark brown in color. In midsummer this stage lasts from three to ten days, four to five days being the usual duration. The pupa stage is easily affected by temperature changes and may be prolonged during hibernation for as long as four or five months. Numerous rearing experiments in various parts of the country have shown that the shortest time between the deposition of eggs and the emergence of the adult fly is eight days, and 10 and 12 day records were very common.

The adult fly, upon emerging from the puparium, works its way upward through the soil or manure and upon reaching the air it crawls about while its wings expand and the body hardens and assumes its normal coloration. In a very few days the female is ready to deposit eggs. In recent experiments it was found that the time between the emergence of the adults and the first deposition of eggs is considerably shorter than previously was thought to be the case. Only three or four days are necessary in midsummer for the female to reach sexual maturity. As in the case of other periods of its life history, so the preoviposition period is prolonged considerably by the lower temperatures of spring and autumn. In midsummer, with a developmental period of from 8 to 10 days from egg to adult, and a preoviposition period of from 3 to 4 days, a new generation would be started every 11 to 14 days. Thus the climate of the District of Columbia allows abundance of time for the development of 10 to 12 generations every summer.

FIG. 9.—Eggs of the house fly. Highly magnified. (Newstead.)

HOW THE HOUSE FLY PASSES THE WINTER.

The prevailing opinion that the house fly lives through the winter as an adult, hiding in cracks and crevices of buildings, etc., appears to be erroneous. Under outdoor conditions house flies are killed during the first really cold nights, that is, when the temperature falls to about 15° or 10° F. In rooms and similar places protected from winds and partially heated during the winter flies have been kept alive in cages for long periods; but they never lived through

the entire winter. In several cases longevity records of from 52 to 54 days were obtained. In other experiments one record of 70 days and another of 91 days was obtained. The average temperature of these experiments varied from 44° to 57° F. The conditions of these experiments seemed to have been most favorable, but flies normally do not seek such places. No uncaged house flies were found during three seasons' observations in unheated and only partially heated attics, stables, unused rooms, etc., where favorable temperature conditions prevailed. The common occurrence in such places of the cluster fly and a few other species, which may be easily mistaken for the house fly, is responsible for the prevailing belief as to the way the house fly overwinters. There is therefore no reliable evidence whatever that adult house flies emerging during October and November pass the winter and are able to deposit their eggs the following spring, although they may continue active in heated buildings until nearly the end of January. On the other hand, there is evidence that house flies pass the winter as larvæ and pupæ, and that they sometimes breed continuously throughout the winter. In experiments at both Dallas, Tex., and Bethesda, Md., house flies have been found emerging during April from heavily infested manure heaps which had been set out and covered with cages during the preceding autumn, this proving that it is possible for them to overwinter as larvæ and pupæ in manure heaps or in the soil beneath such heaps.

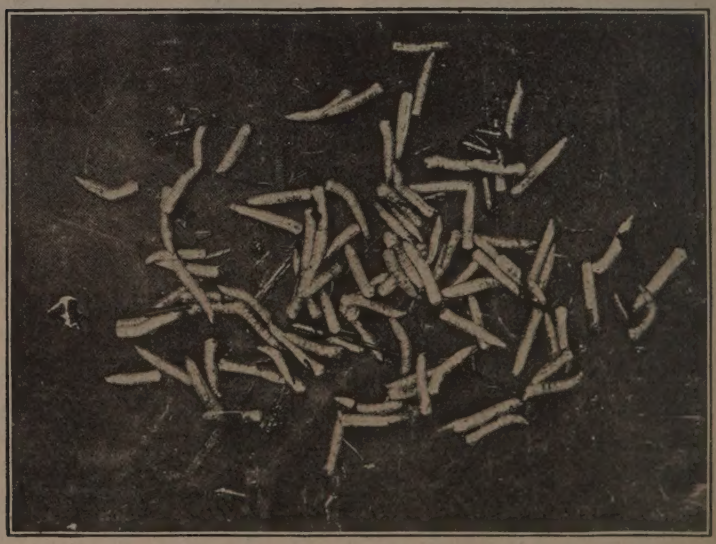

FIG. 10.—Larvæ, or maggots, of the house fly. About natural size. (Newstead.)

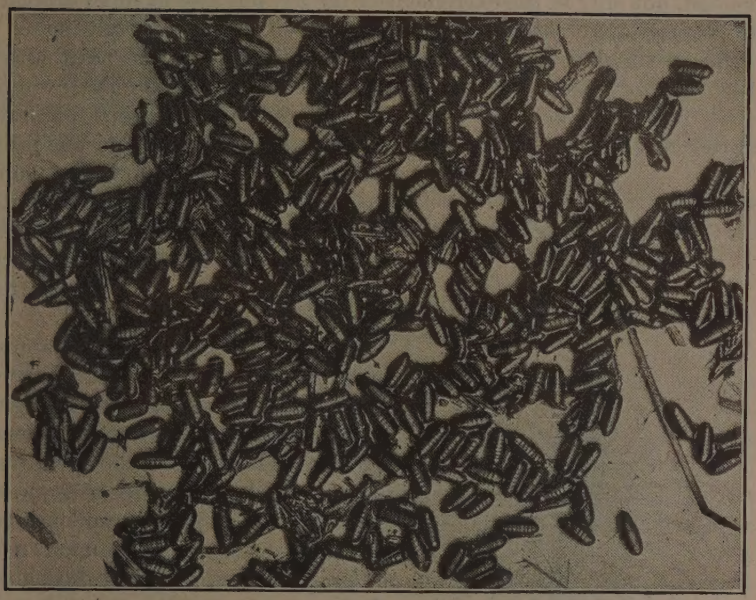

FIG. 11.—Pupæ of the house fly. About natural size. (Newstead.)

The second way in which the house fly may pass the winter is by continuous breeding. As is well known, house flies congregate in heated rooms with the approach of the winter season. If no food or breeding materials are present they eventually will die. Where they have complete access to food they may persist as late as the end of January. However, where they have access to both food and suitable substances for egg laying they will continue breeding just as they do outdoors during the summer. Rearing experiments have been conducted in a bakery, in greenhouses, and in animal breeding houses during winter seasons. Even in very cold climates there are undoubtedly many places, especially in cities, where house flies would have opportunity to pass the winter in this manner.

CARRIAGE OF DISEASE BY THE HOUSE FLY.

The body of the house fly is covered thickly with hairs and bristles of varying lengths, and this is especially true of the legs. Thus, when it crawls over infected material it readily becomes loaded with germs, and subsequent visits to human foods result in their contamination. Even more dangerous than the transference of germs on the legs and body of the fly is the fact that bacteria are found in greater numbers and live longer in the alimentary canal. These germs are

voided, not only in the excrement of the fly, but also in small droplets of regurgitated matter which have been called "vomit spots." When we realize that flies frequent and feed upon the most filthy substances (it may be the excreta of typhoid or dysentery patients or the discharges of one suffering from tuberculosis), and that subsequently they may contaminate human foods with their feet or excreta or vomit spots, the necessity and importance of house-fly control is clear.

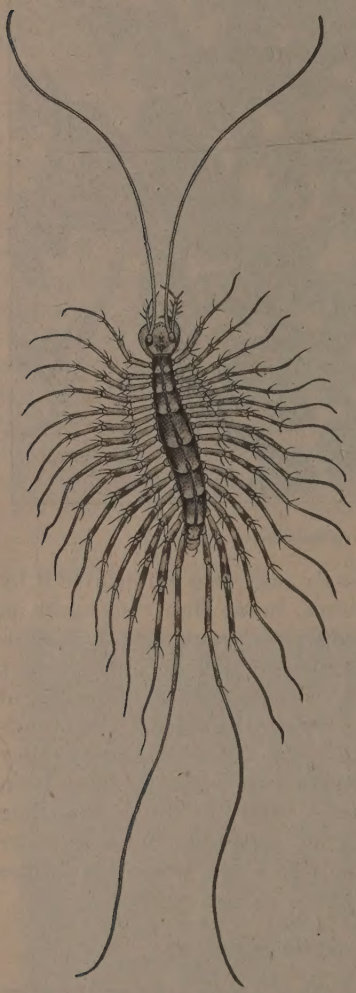

FIG. 12.—The house centipede (*Scutigera forceps*): Adult. Natural size. (Marlatt.)

In army camps, in mining camps, and in great public works, where large numbers of men are brought together for a longer or shorter time, there is seldom the proper care of excreta, and the carriage of typhoid germs from the latrines and privies to food by flies is common and often results in epidemics of typhoid fever.

And such carriage of typhoid is by no means confined to great temporary camps. In farmhouses in small communities, and even in badly cared for portions of large cities, typhoid germs are carried from excrement to food by flies, and the proper supervision and treatment of the breeding places of the house fly become most important elements in the prevention of typhoid.

In the same way other intestinal germ diseases, such as Asiatic cholera, dysentery, and infantile diarrhea, are all so carried. There is strong circumstantial evidence also that tuberculosis, anthrax, yaws, ophthalmia, smallpox, tropical sore, and the eggs of parasitic worms may be and are carried in this way. Actual laboratory proof exists in the case of a number of these diseases, and where lacking is replaced by circumstantial evidence amounting almost to certainty.

NATURAL ENEMIES OF THE HOUSE FLY.

The house fly has a number of natural enemies. The common house centipede (fig. 12) destroys it in considerable numbers; there is a small reddish mite which frequently covers its body and gradually destroys it; it is subject to the attacks of four-winged wasplike parasites in its larva and pupa condition; and it is destroyed by predatory beetles and ants at the same time.

The most effective enemy of the house fly, however, is a fungous disease,[1] which carries off flies in large numbers, particularly toward the close of the season.

CONTROL MEASURES.

THE USE OF SCREENS.

A careful screening of windows and doors during the summer months, with the supplementary use of sticky fly papers, is a protective measure against house flies known to everyone. As regards screening it is only necessary here to emphasize the importance of keeping food supplies screened or otherwise covered so that flies can gain no access to them. This applies not only to homes, but also to stores, restaurants, milk shops, and the like. Screening, of course, will have no effect in decreasing the number of flies, but at least it has the virtue of lessening the danger of contamination of food.

FLY PAPERS AND POISONS.

The use of sticky fly papers to destroy flies that have gained access to houses is well known. Fly-poison preparations also are common. Many of the commercial fly poisons contain arsenic, and their use in the household is attended with considerable danger, especially to children. This danger is lessened by the use of a weak solution of formalin. A very effective fly poison is made by adding 3 teaspoonfuls of the commercial formalin to a pint of milk or water sweetened with a little brown sugar.

The United States Public Health Service recommends a 1 per cent solution of sodium salicylate as almost equally effective. This is prepared by dissolving 3 teaspoonfuls of the pure chemical (a powder) in a pint of water, some brown sugar being added to render it more attractive to flies. A convenient way of exposing these poisons is by partly filling an ordinary drinking glass with the solution. A saucer or plate is then lined with white blotting paper cut the size of the dish and placed bottom up over the glass. The whole is then quickly inverted and a small match stick placed under the edge of the glass. As the solution evaporates from the paper more flows out from the glass and thus the supply is automatically renewed.

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[1] *Empusa muscae.*

FLYTRAPS.

Flytraps may be used to advantage in decreasing the number of flies. Their use has been advocated not only because of the immediate results, but because of the chances that the flies may be caught before they lay their first batch of eggs, and that thus the possible number of future generations will be reduced greatly.

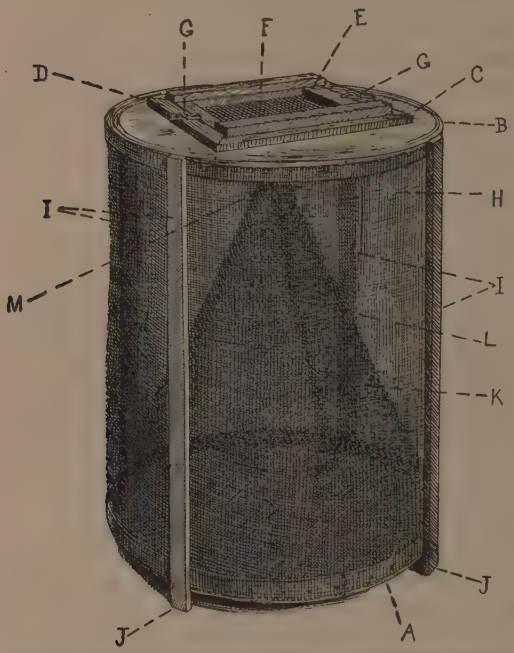

FIG. 13.—Conical hoop flytrap; side view. *A*, Hoops forming frame at bottom. *B*, Hoops forming frame at top. *C*, Top of trap made of barrel head. *D*, Strips around door. *E*, Door frame. *F*, Screen on door. *G*, Buttons holding door. *H*, Screen on outside of trap. *I*, Strips on side of trap between hoops. *J*, Tips of these strips projecting to form legs. *K*, Cone. *L*, United edges of screen forming cone. *M*, Aperture at apex of cone. (Bishopp.)

Many types of flytraps are on the market, and as a rule the larger ones are the more effective. Anyone with a few tools, however, can construct flytraps for a small part of the price of the ready-made ones. A trap which is very effective in catching flies and is easily made, durable, and cheap, may be made as follows:

"The trap (fig. 13) consists essentially of a screen cylinder with a frame made of barrel hoops, in the bottom of which is inserted a screen cone. The height of the cylinder is 24 inches, the diameter 18 inches, and the cone is 22 inches high, and 18 inches in diameter at the base. Material necessary for this trap consists of four new or secondhand wooden barrel hoops, one barrel head, four laths, 10 feet of strips 1 to 1½ inches wide by one-half inch thick (portions of old boxes will suffice), 61 linear inches of 12 or 14 mesh galvanized screening 24 inches wide for the sides of the trap and 41 inches of screening 26 inches wide for the cone and door, an ounce of carpet tacks, and two turn buttons, which may be made of wood." The cost of the material for this trap is not great, and in many cases

the barrel hoops, barrel head, lath, and strips can be obtained without expense.

"In constructing the trap two of the hoops are bent in a circle (18 inches in diameter on the inside), and nailed together, the ends being trimmed to give a close fit. These form the bottom of the frame (*A*), and the other two, prepared in a similar way, the top (*B*). The top (*C*) of the trap is made of an ordinary barrel head with the bevel edge sawed off sufficiently to cause the head to fit closely in the hoops and allow secure nailing. A square, 10 inches on the side, is cut out of the center of the top to form a door. The portions of the top (barrel head) are held together by inch strips (*D*) placed around the opening one-half inch from the edge to form a jamb for the door. The door consists of a narrow frame (*E*) covered with screen (*F*) well fitted to the trap and held in place (not hinged) by buttons (*G*). The top is then nailed in the upper hoops and the sides (*H*) formed by closely tacking screen wire on the outside of the hoops. Four laths (*I*) (or light strips) are nailed to the hoops on the outside of the trap to act as supports between the hoops, and the ends are allowed to project 1 inch at the bottom to form legs (*J*). The cone (*K*) is cut from the screen and either sewed with fine wire or soldered where the edges meet at *L*. The apex of the cone is then cut off to give an aperture (*M*) 1 inch in diameter. It is then inserted in the trap and closely tacked to the hoop around the base."[1]

The effectiveness of the traps will depend on the selection of a good bait. For attracting house flies beer is probably the best. It loses much of its attractiveness after the first stages of fermentation are over, and for this reason it should be renewed every day or two. Milk is also a good bait. Overripe or fermenting bananas crushed and placed in the bait pans give good results. A combination of bananas and milk is more attractive than either used separately. A mixture of 3 parts water and 1 part cheap molasses is very attractive after it has been allowed to ferment for a day or two. A mixture of equal parts brown sugar and cheese (or curd of sour milk), thoroughly moistened, gives good results after it has been allowed to stand for three or four days. For catching blowflies and other meat-infesting flies the best bait is the mucous membrane from the lining of the intestines of hogs. Ordinary fish or meat scraps may be used.

PREVENTIVE MEASURES.

Fly papers, poisons, and traps are at best only temporary expedients. The most logical method of abating the fly nuisance is the elimination or treatment of all breeding places. It would appear from what is known of the life history and habits of the common house

[1] Bishopp, F. C. Flytraps and their operation. U. S. Dept. Agr. Farmers' Bul. 734, p. 3–5. 1916.

fly that it is perfectly feasible for cities and towns to reduce the numbers of these annoying and dangerous insects so greatly as to render them of comparatively slight account.

CONSTRUCTION AND CARE OF STABLES.

In formulating rules for the construction and care of stables and the disposal of manure the following points must be taken into consideration. In the first place, the ground of soil-floor stables may offer a suitable place for the development of fly larvæ. The larvæ will migrate from the manure to the soil and continue their growth in the moist ground. This takes place to some extent even when the manure is removed from the stables every day. Even wooden floors are not entirely satisfactory unless they are perfectly water-tight, since larvæ will crawl through the cracks and continue their development in the moist ground below. Water-tight floors of concrete or masonry, therefore, are desirable. Flies have been found to breed in surprising numbers in small accumulations of material in the corners of feed troughs and mangers, and it is important that such places be kept clean.

FLY-TIGHT MANURE PITS OR BINS.

The Bureau of Entomology for some years has advised that manure from horse stables be kept in fly-tight pits or bins. Such pits can be built in or attached to the stable so that manure can be easily thrown in at the time of cleaning and so constructed that the manure can be readily removed. The essential point is that flies be prevented from reaching the manure, and for this reason the pit or bin must be tightly constructed and the lid kept closed except when the manure is being thrown in or removed. The difficulty has been that manure often becomes infested before it is put into the container, and flies frequently breed out before it is emptied and often escape through the cracks. To obviate these difficulties a manure box or pit with a modified tent trap or cone trap attached is desirable.

In order to retain the fertilizing value of manure to the greatest extent it is advisable that air be excluded from it as much as possible and that it be protected from the leaching action of rains. This being the case, there is really no necessity for covering a large portion of the top of the box with a trap, but merely to have holes large enough to attract flies to the light, and to cover these holes with ordinary conical traps, with the legs cut off, so that the bottoms of the traps will fit closely to the box. The same arrangement can be made where manure is kept in a pit.

FREQUENCY WITH WHICH MANURE SHOULD BE REMOVED.

Another point must be considered in deciding the question as to how often the manure should be removed. In this connection it should be borne in mind that when the larvæ have finished feeding

they will often leave the manure and pupate in the ground below or crawl some distance away to pupate in débris under boards or stones and the like. Hence the manure should be removed before the larvæ reach the migratory stage; that is to say, removal is necessary every three days, and certainly not less frequently than twice a week during the summer months. A series of orders issued in 1906 by the health department of the District of Columbia, on the authority of the Commissioners of the District, covers most of these points, and these orders, which may well serve as a model to other communities desiring to undertake similar measures, may be briefly condensed as follows:

HEALTH OFFICE REGULATIONS FOR CONTROL OF HOUSE FLIES IN CITIES.

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain in connection therewith a bin or pit for the reception of manure and, pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water and shall in all other respects be water-tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle, which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of the provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

Not only must horse stables be cared for, but chicken yards, piggeries, and garbage receptacles as well. In cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very long, when window screens may be discarded.

DISPOSAL OF MANURE IN RURAL AND SUBURBAN DISTRICTS.

The control of flies in rural and suburban districts offers a much more difficult problem. Here it is out of the question to remove all manure from the premises twice a week. The problem is rather to find some method of disposal or storage which will conserve the fertilizing value of the manure and at the same time prevent all flies from breeding or destroy such as do breed there.

With this idea in mind, it has been recommended that stable manure be removed every morning and hauled out at once and spread rather thinly on the fields. This procedure is advisable from the point of view of getting the maximum fertilizing value from the manure. Immediate spreading on the fields is said largely to prevent the loss of plant food which occurs when manure is allowed to stand in heaps for a long time. This method will be effective in preventing the breeding of flies only if the manure is hauled out promptly every morning and spread thinly so that it will dry, since it is unfavorable for fly development in dessicated condition. Removal every three or four days will not be sufficient. Observations have shown that if manure becomes flyblown and the maggots attain a fairly good size before the manure is scattered on the fields, they can continue their development and will pupate in the ground. A further objection is that during the summer months, when fly breeding is going on most actively, the agriculturist is also busy and can seldom spare the time or the teams to carry out such a program regularly.

CHEMICAL TREATMENT OF MANURE TO DESTROY FLY MAGGOTS.

The general practice, therefore, is to remove manure and keep it in heaps located, as a rule, very near the stables. How can fly breeding be prevented in such accumulations? As a result of recent investigations, it is now possible to point out two methods which are practical and effective.

The first is the treatment of the manure pile with chemical substances which will kill the eggs and maggots of the house fly. The Bureau of Entomology, in cooperation with the Bureau of Chemistry and the Bureau of Plant Industry, has conducted a series of experiments in which a large number of chemicals were applied to infested manure and observations made not only on their efficiency in killing the maggots but also as to their effect on the chemical composition and bacterial flora of the manure. The object was to find some cheap chemical which would be effective in destroying the fly larvæ and at the same time would not reduce the fertilizing value of the manure.

TREATMENT WITH HELLEBORE.

Of the numerous substances tried, the one which seems best to fulfill these conditions is powdered hellebore. Some of the powdered hellebore in use is prepared from the roots of a plant which is popularly known as Indian polk or itch weed.[1] It is common in wet grounds and is of wide distribution in the United States. The European species of this plant,[2] however, furnishes the bulk of the supply. Hellebore contains a number of chemical compounds known as alkaloids. Alkaloids are organic substances, of which quinine,

[1] *Veratrum viride.* [2] *Veratrum album.*

morphine, and cocaine may be mentioned as examples, which act very intensely on the animal body. For the treatment of manure a water extract of the hellebore is prepared by adding ½ pound of the powder to every 10 gallons of water, and after stirring it is allowed to stand 24 hours. The stock mixture thus prepared is sprinkled over the manure at the rate of 10 gallons to every 8 bushels (10 cubic feet) of manure. From the result of 12 experiments with manure piles treated under natural conditions it appears that such treatment results in the destruction of from 88 to 99 per cent of the fly larvæ. Amounts of hellebore less than ½ pound to every 8 bushels of manure are not so effective, while stronger applications, of course, will give somewhat better results.

Bacteriological studies of the treated piles proved that the bacteria were not injured or their development retarded, and chemical analysis showed that the composition of the manure was unaltered. Furthermore, several field tests were made in growing cabbages, turnips, lettuce, potatoes, wheat, and a few other crops on plats which had been fertilized with hellebore-treated manure, with the result that there appeared no injury whatever that could be ascribed to the use of this substance. The only possible objection to the use of hellebore seems to be the possibility of poisoning farm animals, as might happen if, for example, the barrel or tank in which the stock solution was prepared were left uncovered in an accessible place. It is quite safe to say that chickens will not be injured by pecking at hellebore-treated manure. This has been tested carefully. Hellebore can be obtained both in ground and powdered form, but the powdered form gives the best results in the destruction of fly larvæ.

TREATMENT WITH POWDERED BORAX.

Another chemical found to be even more effective as a larvicide is powdered borax. This is an inorganic substance, available in commercial form in all parts of the country. It has the advantage of being comparatively nontoxic and noninflammable and is easily transported and handled. The minimum amount necessary to kill fly larvæ was found to be 0.62 pound per 8 bushels of manure, or about 1 pound per 16 cubic feet. Best results were obtained when the borax was applied in solution, or when water was sprinkled on after the borax had been scattered evenly over the pile. Borax is not only effective in killing the larvæ, but when it comes in contact with the eggs it exerts a toxic action which prevents them from hatching. When applied at the rate of 1 pound to 16 cubic feet it was found to kill about 90 per cent of the larvæ, heavier applications killing from 98 to 99 per cent.

Borax had no injurious effect on the composition of the manure; in fact, in some cases the ammonia and water-soluble nitrogen seemed to be increased; nor was there any permanent decrease in the number of bacteria. Borax-treated manure was less subject to the growth of molds and consequent firefanging. Now, although borax does not have any deleterious effect on the chemical composition of manure, yet when added to the soil with the manure it acts directly on plants, and large applications will cause considerable injury. On the other hand, certain investigators have shown that small amounts of borax have a stimulating effect. The question is, therefore, whether any injury to plants will result from the application of manure treated at the rate of 1 pound per 16 cubic feet. To answer this point numerous tests were carried out, both in the greenhouse and under field conditions, using borax-treated manure for fertilizing a number of different crops, such as wheat, potatoes, peas, beans, lettuce, and others. As far as these experiments have gone they indicate that if manure so treated is applied at a rate of not more than 15 tons per acre, no injury, as a rule, will follow. Some plants are more sensitive to the presence of borax than others, however, and the effects are more noticeable on some soils than on others. All crops have not been tested, nor has the cumulative effect of borax treatment been worked out. It is necessary, therefore, to repeat the warning issued in connection with a previous bulletin on this subject, that great care be exercised, in the application of borax, that the manure does not receive more than 1 pound for every 16 cubic feet, and that not more than 15 tons of manure so treated are applied to the acre.

In view of the possible injury from the borax treatment as a result of carelessness in applying it, or from other unforeseen conditions, it is recommended that horse manure and other farmyard manures which are to be used as fertilizer be treated with hellebore. Borax, on the other hand, is such a good larvicide that it can be used with advantage on the ground of soil-floor stables, in privies, on refuse piles, and on any accumulations of fermenting organic matter which are not to be used for fertilizing purposes.

TREATMENT WITH CALCIUM CYANAMID AND ACID PHOSPHATE.

Many experiments with mixtures of commercial fertilizers were tried to determine whether fly larvæ would be killed by any substance the addition of which would increase the fertilizing value of the manure. A mixture of calcium cyanamid and acid phosphate was found to possess considerable larvicidal action. Several experiments showed that ½ pound of calcium cyanamid plus ½ pound of acid phosphate to each bushel of manure gave an apparent larvicidal action of 98 per cent. The mixture in the form of a powder was

scattered evenly over the surface and then wet down with water. The use of this mixture adds to the manure the important elements, nitrogen and phosphorus.

Of course there are a number of other insecticides which are effective against fly larvæ. Potassium cyanid, Paris green, arsenite of soda, etc., are effective, but they are hardly to be recommended for general use because of their extremely poisonous nature. Others, like pyridine, aniline, and nitrobenzene emulsion, are too expensive when used in amounts sufficient to kill maggots.

MAGGOT TRAP FOR DESTRUCTION OF FLY LARVÆ FROM HORSE MANURE.

The second method of handling manure is one which does not require the application of chemicals. It is based on the fact, mentioned on page 6, that the larvæ of the house fly, when about ready to pupate, show a very strong tendency to migrate, leaving the spot where they have been feeding and crawling about in search of a suitable place for pupation. This migration takes place mostly at night, and the larvæ sometimes crawl considerable distances away from the manure pile. Now it is possible by means of a very simple arrangement called a maggot trap to destroy fully 99 per cent of all maggots breeding in a given lot of manure. A successful maggot trap which the Maryland Agricultural College constructed at the college barn is shown in figure 14. The trap was designed by the

FIG. 14.—A maggot trap for house-fly control. View of the maggot trap, showing the concrete basin containing water in which larvæ are drowned, and the wooden platform on which manure is heaped. (Hutchison.)

junior author and constructed under his supervision. The manure, instead of being thrown on the ground, is heaped carefully on a slatted platform, which stands about 1 foot high. This particular platform measures 10 by 20 feet. There are six 2 by 4 pieces running lengthwise 2 feet apart. Across these are nailed 1-inch strips with ½ to 1 inch spaces between them. The wooden platform stands on a concrete floor, and a rim or wall of concrete 4 inches high surrounds the floor. The floor slopes a little toward one corner, from which a pipe leads to a small cistern near by. This pipe is plugged with a stopper of soft wood, and the concrete floor is filled with water to a depth of 1 inch in the shallowest part. The manure is then heaped on the platform each morning when it is removed from the stable. Flies will lay their eggs on the manure as usual, but the maggots, when they have finished feeding and begin to migrate, crawl out of the manure, drop into the water below, and are drowned. Each week

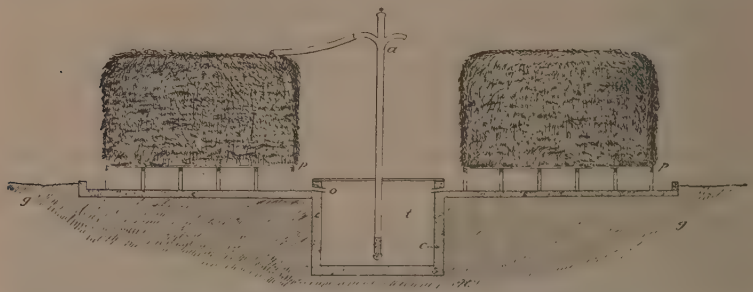

FIG. 15.—Imaginary cross section of an arrangement suggested for use where manure production is large. *a*, Pump; *c*, concrete floor and walls of cistern; *o*, outlet pipes leading from floor of maggot trap to cistern; *p*, platform maggot trap; *t*, cistern for liquid manure; *g*, ground level. (Hutchison.)

the plug is removed from the pipe, and all the maggots are washed into the cistern. The floor is then cleaned of any solid particles by means of a long-handled stable broom or by a strong stream of water from a hose. The pipe being again plugged, the floor is again partly filled with water and the trap is ready for another week's catch. A platform of this size will hold the manure accumulating from four horses during the period of four months, or about 20 days' accumulation from 25 horses, if the heap is well built and made at least 5 feet high.

Experience with maggot traps has brought out the following points. In the first place, the trap is more effective when the manure is kept compactly heaped and well moist. This is to be explained by the fact that the larvæ seek a comparatively dry place in which to pupate, and crawl away from wet manure. A cistern should be built close to the trap and a pump fitted so that liquids can be pumped onto the heap. (Fig. 15.) Each day, after the litter from the stable

has been thrown onto the heap, just enough water should be added to moisten it thoroughly without causing leaching. The ideal arrangement would be to have water-tight floors in the stalls and drains leading to the cistern. The liquid manure collecting in the cistern could be pumped onto the manure heap, thus not only maintaining the moisture content necessary to insure the greatest amount of migration, but also adding to the manure the valuable constituents of the urine. It happens, too, that keeping the manure carefully heaped and watered promotes the anaerobic fermentation and tends to prevent to some degree the loss of ammonia and gaseous nitrogen.

In the second place, the platform should stand not less than 1 foot above the concrete floor. This is to facilitate cleaning the floor of maggots and the débris which unavoidably accumulates there. The floor should be cleaned at least once a week, and all liquids run into the cistern in order to prevent mosquitoes from breeding in the water in the floor of the trap. A thin film of oil can be used to prevent mosquito breeding in the cistern.

A third point of importance is that old manure is unfavorable for fly breeding. Experiments have shown that after manure has been standing on a maggot trap for 8 to 10 days it is practically free from maggots, and no more will appear in it. This means that a given lot of manure need remain on the maggot trap for only 10 days in order to prevent any breeding taking place in it.

The maggot trap is simple, easily constructed, and cheap. Practically the only cost is the initial one for construction. Very little extra labor is required to operate it. Only a few minutes each day are necessary to water the manure after the stable cleanings have been added to the heap. Cleaning the floor to dispose of the maggots and to prevent mosquito breeding will take about half an hour once a week.

That the maggot trap is effective has been shown by the junior author's observations at the Maryland Agricultural College. It was found that the trap destroyed 99 per cent of the larvæ breeding there and that the number of flies at the barn and around the college kitchen was reduced 67 to 76 per cent. That the reduction in the prevalence of flies was not equal to the percentage of larvæ destroyed was ascribed to the fact that several other piles of untreated manure were breeding out flies at near-by stables, and from these places they were attracted to the barn and kitchen.

Maggot traps may be constructed in almost any size and to suit almost any conditions, and appear to be especially adapted to meet the problem of fly control under rural conditions.

COMPACT HEAPING OF MANURE.

Another method of disposing of manure has been recommended by English writers, as a result of experience in preventing fly breeding in the large accumulations of horse manure around army camps. A rectangular area of ground is staked off and the daily accumulations of manure are hauled on to this area, and dumped. It is then built up into a compact heap, the sides of which are straight and beaten hard with shovels. The ground around the edges of the heap is made smooth and hard and then some loose straw is placed in small windrows around the manure pile about 1 foot from the edge. By pressing down the manure into a compact heap, air is excluded from the interior. This condition, together with the high temperature and gases formed by fermentation, tends to make the heap an unfavorable place for the development of fly larvæ. Those which do happen to develop in the surface layers will migrate when fully fed and pupate in the ring of straw around the heap. This straw, with pupæ in it, is swept up every two or three days and burned.

TREATMENT OF MISCELLANEOUS BREEDING PLACES.

It is just as true under farm conditions as in cities that breeding places other than horse manure must be attended to. Garbage must be disposed of, hog and poultry manure must be cared for, and especially on dairy farms it is extremely important that every precaution be taken to prevent the contamination of milk by flies. Care and cleanliness, combined with some of the arrangements just described, will measurably affect the fly nuisance in neighboring buildings.

SEWAGE DISPOSAL IN RELATION TO THE PREVENTION OF FLY-BORNE DISEASES.

In the consideration of these measures we have not touched upon the remedies for house flies breeding in human excrement. On account of the danger of the carriage of typhoid fever, the dropping of human excrement in the open in cities or towns, either in vacant lots or in dark alleyways, should be made a misdemeanor, and the same care should be taken by the sanitary authorities to remove or cover up such depositions as is taken in the removal of the bodies of dead animals. For modern methods of sewage disposal adapted for farm use one should consult Department of Agriculture Bulletin No. 57, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents. In the absence of modern methods of sewage disposal, absolutely sanitary privies are prime necessities, whether in towns or on farms. Directions for the building and caring for such privies will be found in Farmers' Bulletin 463 and in Yearbook Separate 712, "Sewage Disposal on the Farm." The box privy is always a nuisance from many points of view, and is undoubtedly dangerous as a breeder of flies which may carry the germs of intestinal diseases. The dry-earth

treatment of privies is unsatisfactory. No box privy should be permitted to exist unless it is thoroughly and regularly treated with some effective larvicide. Since the fecal matter in such privies is seldom used for fertilizing purposes it may well be treated liberally with borax. The powdered borax may be scattered over the exposed surface so as to whiten it. An application two or three times a week during the fly season ought to prevent all fly breeding in such matter.

WHAT COMMUNITIES CAN DO TO ELIMINATE THE HOUSE FLY.

Antifly crusades have been very numerous in recent years, and some have been noteworthy both in methods and in results. However, it will not be amiss here to emphasize the importance of concerted, organized effort on the part of whole communities, not only cities, but suburban and rural neighborhoods as well. By the most painstaking care one may prevent all fly breeding on his premises, but it will avail him little if his neighbors are not equally careful. Some sort of cooperation is necessary. One of the first and most important elements in any antifly crusade is a vigorous and continued educational campaign. It has been the experience of those who have undertaken such crusades that people generally regard the fly as a somewhat harmless nuisance and that the first work of the campaign was to bring the people to a realization of the dangers from flies and the possibility of getting rid of them. In the educational campaign every possible means of publicity can be employed, including newspapers, lectures, moving pictures, posters, handbills, cartoons, instruction in schools, etc.

The antifly crusade is a matter of public interest and should be supported by the community as a whole and engineered by the health officers. But health officers can do little toward the necessary work of inspection and elimination without funds, and therefore the support of the campaign must manifest itself in increased appropriations for public-health work. Very often it is lack of funds which prevents the health officers from taking the initiative in the antifly crusades, and there must necessarily be much agitation and education before they can profitably take up the work. Right here lies a field for civic associations, women's clubs, boards of trade, etc., to exercise their best energy, initiative, and leadership.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO HOUSEHOLD INSECTS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Remedies and Preventives Against Mosquitoes. (Farmers' Bulletin 444.)
Some Facts About Malaria. (Farmers' Bulletin 450.)
The Sanitary Privy. (Farmers' Bulletin 463.)
The Yellow Fever Mosquito. (Farmers' Bulletin 547.)
The Carpet Beetle, or "Buffalo Moth." (Farmers' Bulletin 626.)
The House Centipede. (Farmers' Bulletin 627.)
Cockroaches. (Farmers' Bulletin 658.)
The True Clothes Moths. (Farmers' Bulletin 659.)
The Silverfish: An Injurious Household Insect. (Farmers' Bulletin 681.)
Fleas as Pests of Man and Animals, with Suggestions for Their Control. (Farmers' Bulletin 683.)
Hydrocyanic-acid Gas Against Household Insects. (Farmers' Bulletin 699.)
House Ants: Kinds and Methods of Control. (Farmers' Bulletin 740.)
The Bedbug. (Farmers' Bulletin 754.)
White Ants as Pests in the United States and Methods of Preventing Their Damage. (Farmers' Bulletin 759.)
Carbon Disulphid as an Insecticide. (Farmers' Bulletin 799.)
A Maggot Trap in Practical Use: An Experiment in House-Fly Control. (Department Bulletin 200.)
Further Experiments in the Destruction of Fly Larvæ in Horse Manure. (Department Bulletin 245.)
Argentine Ant: Distribution and Control in the United States. (Department Bulletin 377.)
European Earwig and Its Control. (Department Bulletin 566.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The Migratory Habit of House-Fly Larvæ as Indicating a Favorable Remedial Measure. An Account of Progress. (Department Bulletin 14.) 1914. Price, 5 cents.
Experiments in the Destruction of Fly Larvæ in Horse Manure. (Department Bulletin 118.) 1914. Price, 10 cents.
Fleas. (Department Bulletin 248.) 1915. Price, 10 cents.
Termites, or "White Ants," in the United States: Their Damage and Methods of Prevention. (Department Bulletin 333.) 1916. Price, 15 cents.
Notes on the Preoviposition Period of the House Fly. (Department Bulletin 345.) 1916. Price, 5 cents.
Experiments during 1915 in the Destruction of Fly Larvæ in Horse Manure. (Department Bulletin 408.) 1916. Price, 5 cents.
Principal Household Insects of United States, with Chapter on Insects Affecting Dry Vegetable Foods. (Entomology Bulletin 4, n. s.) 1896. Price, 10 cents.
Notes on Mosquitoes of United States, Giving Some Account of Their Structure and Biology, with Remarks on Remedies. (Entomology Bulletin 25, n. s.) 1900. Price, 10 cents.
Economic Loss to People of United States Through Insects that Carry Disease. (Entomology Bulletin 78.) 1909. Price, 10 cents.
Preventive and Remedial Work Against Mosquitoes. (Entomology Bulletin 88.) 1910. Price, 15 cents.
Argentine Ant. (Entomology Bulletin 122.) 1913. Price, 25 cents.

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